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Multimodal Platform Control for Robotic Planetary Exploration Missions

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Abstract:

Planetary exploration missions pose unique problems for astronauts seeking to coordinate and control exploration vehicles. These include working in an environment filled with abrasive dust (e.g., regolith compositions), a desire to have effective hands-free communication, and a desire to have effective analog control of robotic platforms or end effectors. Requirements to operate in pressurized suits are particularly problematic due to the increased bulk and stiffness of gloves. As a result, researchers are considering alternative methods to perform fine movement control, for example capitalizing on higher-order voice actuation commands to perform control tasks.

This paper presents current research at NASA's Neuro Engineering Laboratory that explores one method—direct bioelectric interpretation—for handling some of these problems. In this type of control system, electromyographic (EMG) signals are used both to facilitate understanding of acoustic speech in pressure-regulated suits and to provide smooth analog control of a robotic platform, all without requiring fine-grained hand movement. This is accomplished through the use of non-invasive silver silver-chloride electrodes located on the forearm, throat, and lower chin, positioned so as to receive electrical activity originating from the muscles during contraction. For direct analog platform control, a small Personal Exploration Rover (PER) built by Carnegie Mellon University Robotics is controlled using forearm contraction duration and magnitudes, measured using several EMG channels. Signal processing is used to translate these signals into directional platform rotation rates and translational velocities. Higher order commands are generated by differential contraction patterns called "clench codes."

The interface between the continuous analog control activity and higher order planning and state communication is accomplished through the use of subvocal speech. Subvocal speech is the term given to EMG-based speech recognition. It can be used either as a stand-alone control technique or as a supplement to conventional (e.g., acoustic) automatic speech recognizers. Its great advantage is that it is immune from ambient

acoustic noise. Initial experiments using this mixed system are described where both clench code and subvocal control is used to direct the PER platform while wearing a self-contained breathing apparatus (SCBA). On a 15-word English vocabulary, an SCBA-wearing user achieved a 74% average correct recognition rate using the subvocal speech system. Other recognition results and general platform performance observations are discussed. Future work will look to increase the degree of control of the robot available to system users.